THE FIRST BROAD-BAND PERSISTENT X-RAY SPECTRUM OF THE DIPPING LOW MASS X-RAY BINARY EXO 0748-676

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ABSTRACT

We report on the results of a BeppoSAX observation of the dipping LMXRB EXO 0748-676 performed in 2000 November. This is the first simultaneous observation of this source over the 0.1-100 keV energy range. The persistent spectrum is complex and shows a soft excess, which requires the inclusion of an ionized absorber (with a sub-solar abundance of iron). A cutoff power-law is a good fit to the high energy part of the spectrum, with a photon index of 1.3 and a cutoff around 50 keV. The 0.1-100 keV luminosity is 8.2×10^{36} erg s^{-1}.

Key words: X-rays; Individual:EXO 0748-676 .

1. INTRODUCTION

EXO 0748-676 is a transient LMXRB discovered with EXOSAT (Parmar et al., 1986) with a 3.82 hr orbital period measured from its X-ray eclipses. It is a type I X-ray burster and displays quasi periodic oscillations (discovered with RossiXTE, Homan et al., 1999; Homan & van der Klis, 2000) as well as intensity dips and X–ray eclipses (Parmar et al. 1986; Church et al., 1998).

It shows a complex soft X-ray spectrum (Thomas et al., 1997). Church et al. (1998), analysing dip and non-dip ASCA spectra, interpreted the source spectrum as composed by an extended Accretion Disk Corona (ADC), producing the hard emission, plus a point-like soft black-body emission. The spectral evolution during dipping is explained with the progressive covering of the ADC emission.

A different view on the system came from EPIC/XMM-Newton observations, which revealed a persistent (i.e., no dipping and no eclipsing) spectrum composed by an extended thermal halo together with a highly absorbed, and more compact, high energy power-law produced in the ADC (Bonnet-Bidaud et al., 2001).

RGS/XMM-Newton observations detected absorption and emission lines from ionized Ne, O and N (Cottam et al.,2001).

The cumulative RGS spectra during type I X-ray bursts revealed iron absorption lines, from which a gravitational redshift of z=0.35 have been measured (Cottam et al., 2002).

Chandra observations confirmed the presence of photoionized plasma, probably located above the accretion disk. The Chandra spectrum during dips was absorbed both by neutral and ionized material (Jimenez-Garate et al., 2003).

A recent analysis of several XMM-Newton observations revealed for the first time the clear detection of eclipses below 2 keV (Homan et al. 2003).

2. BEPPOSAX OBSERVATIONS

The source was observed with BeppoSAX in 2000, November, for an on-source time of 66 ks. We report here spectral results from all the instruments onboard BeppoSAX: LECS (0.1-10 keV), MECS (1.8-10.8 keV), HPGSPC (5-120 keV) and PDS (15-200 keV) (Sidoli et al., 2004).

The source lightcurve in the 1.8-10 keV band is shown in Fig. 1, where all kind of variabilities typical of this source are evident: X–ray eclipses, dips, type I X–ray bursts.

3. SPECTRAL RESULTS

We concentrate here on the "persistent" spectrum (no-dipping, no-eclipsing, no-bursting spectrum). In order to select the persistent emission, we considered only events where the source displays a constant low hardness ratio (see Fig. 2).

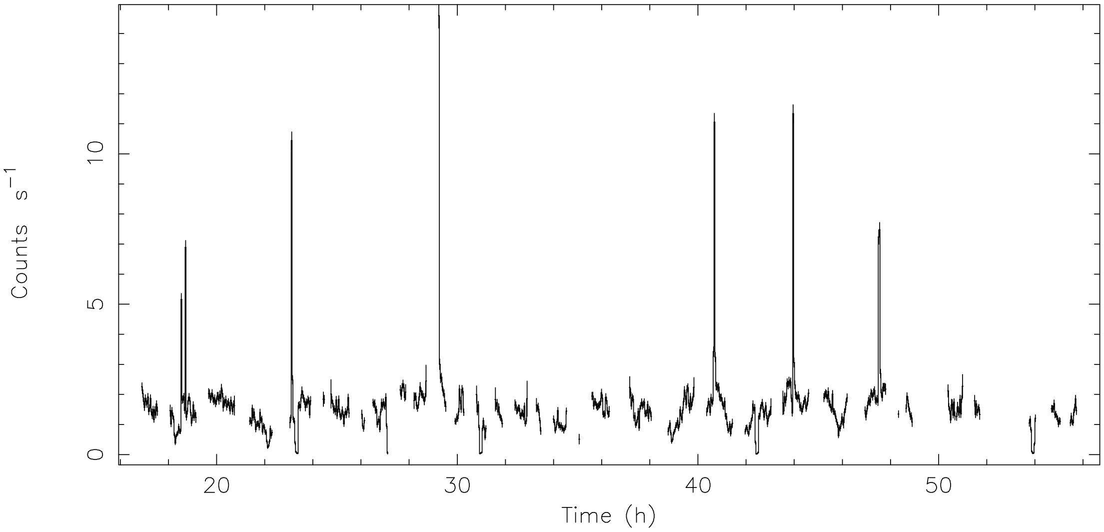

Figure 1. BeppoSAX MECS lightcurve (1.8-10 keV) with a time binning of 128s. Type I X-ray bursts, dips, and eclipses are clearly evident

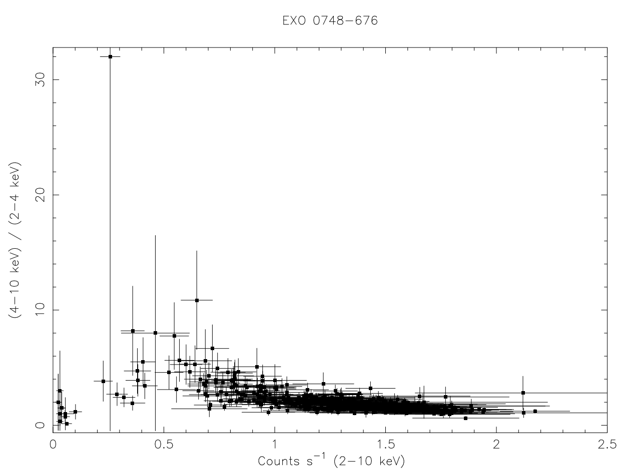

Figure 2. EXO 0748-676 hardness ratio versus 2–10 keV intensity. Time intervals containing bursts have been excluded. In order to consider only events with a low hardness ratio we selected 2–10 keV intensity >1.5 s^{-1}

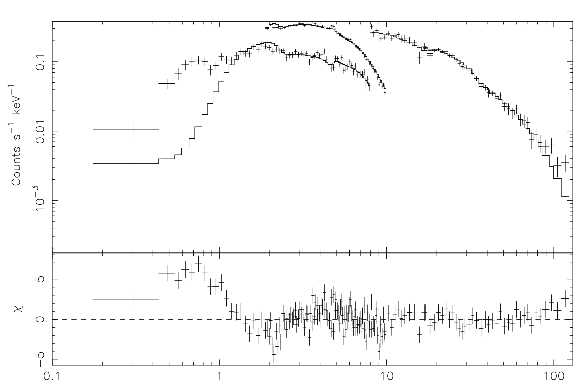

Figure 3. The fit to the BeppoSAX persistent spectrum with an absorbed cutoff powerlaw clearly is inadequate and shows a soft excess. The lower panel shows the residuals in units of standard deviations

We tried to fit the "persistent" spectrum with several models, all including a high energy cut-off powerlaw in order to account for the high energy part of the spectrum. In Fig. 2 the count spectrum (together with the residuals) is reported, fit with an absorbed cut-off powerlaw. There is clearly evidence for a soft excess and other structured residuals, especially in the low energy part of the spectrum. Trying to model this soft excess with soft components (blackbody or hot plasma models (i.e. MEKAL in XPSEC)) or different kinds of absorptions (e.g. partial covering model, differential absorbing models for the soft and the hard spectral components) resulted in non-satisfactory fits (χ^2 >2).

Among all spectral deconvolutions tested, a cut-off power-law absorbed with an ionized absorber (with a non-solar iron abundance) resulted in a significanlty better fit. An additional absorption line at ∼2.16 keV is needed to get a good fit to the spectrum (see Table 1 for the best-fit parameters).

Currently a reanalysis of the data is in progress taking into account the recent results of Homan et al. (2003) who found a change in the spectrum below 2 keV, which is not visible above 2 keV (i.e. our selection criterion). This represents low-level dipping activity and might cause "mixing" of spectra which might affect our results at low energies.

4. CONCLUSIONS

We have discussed here the first observation of the broad-band X–ray emission of the dipping LMXRB EXO 0748-676 showing that this source displays significant emission up to 100 keV.

The best-fit model to the "persistent" spectrum consists of a cut-off power-law, extra-absorbed at low energies by an ionized absorber with non-solar iron

Table 1. Best-fit parameters for the broad-band BeppoSAX "persistent" spectrum of EXO 0748-676. The meaning of the symbols is the following: $N_{\rm H}$ is the interstellar column density, $N_{\rm absori}$ is the local absorbing column density due to the ionized absorber. ξ is the ionization parameter (ξ=L/nR^2, where L is the luminosity of the X–ray illuminating source, n is the absorbing plasma density and R is the distance of the absorbing matter from the ionizing source). The parameters of the cut-off power-law are Γ, the cut-off power-law photon index and $E_{\rm c}$, the high energy cut-off. $E_{\rm line}$ is the centroid energy of the absorption line with a width σ and an intensity $I_{\rm line}$. The fluxes reported here are "observed" fluxes (not corrected for the absorption). The luminosity has been corrected only for interstellar absorption and calculated for a distance of 10 kpc

Parameter	Value
$N_{\rm H}$ (10^{22} cm^{-2})	$0.12^{+0.03}_{-0.02}$
$N_{\rm absori}$ (10^{22} cm^{-2})	5^{+3}_{-1}
ξ	250 ± 60
Fe abundance	$0.6^{+0.3}_{-0.4}$
Γ	$1.33^{+0.08}_{-0.05}$
$E_{\rm c}$ (keV)	47 ± 7
$E_{\rm line}$ (keV)	$2.16^{+0.05}_{-0.04}$
$I_{\rm line}$ (10^{-4}photons cm^{-2} s^{-1})	$-4.2^{+1.5}_{-2.0}$
EW (eV)	-40^{+15}_{-20}
Flux (2–10 keV) (erg cm^{-2} s^{-1})	1.7×10^{-10}
Flux (0.1–100 keV) (erg cm^{-2} s^{-1})	6.9×10^{-10}
Luminosity (2–10 keV) (erg s^{-1})	2.0×10^{36}
Luminosity (0.1–100 keV) (erg s^{-1})	8.2×10^{36}
χ^2/dof	189.6/168

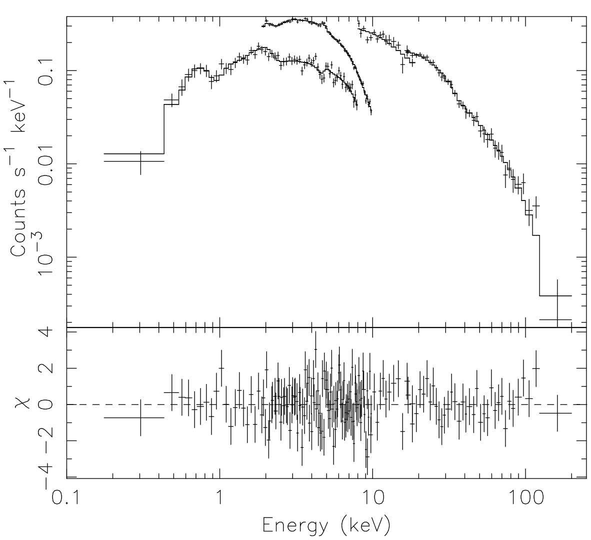

Figure 4. BeppoSAX best-fit: cut-off powerlaw with an ionized absorber. See Table 1 for the spectral parameters

abundance. The need for an ionized absorber indicates that absorbing matter local to the binary system is located over most or all of the orbital period.

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